The 9th East Asia
Partial Differential Equations
Conference

July 28–31, 2014

Program & Abstract

Hotel Nikko Nara, Nara, Japan
Objectives

Since 17th century, the theory of partial differential equation (PDE) has been a central subject of analysis, mathematics, and natural science. Especially in the last century, PDE has been rapidly developed through their interaction with geometry, life science, physics and engineering, with the aid of matured real analysis and abstract analysis, and we have no doubt that this tendency will last to the middle of this century. In order to understand widely, deeply and rapidly developed study exactly, introduce them to our research, and let the results know others, sound promotion of the community of researchers is indispensable, and it must start from the communication with neighbors before anything else. Being based on the concept above, we the PDE group of Osaka University intend to promote the place where researchers in the East Asia can come together, announce the result of their researches, and discuss them with each other. (31 March, 2001)

Activities

- "The East Asia Symposium Partial Differential Equations Conferences" are conferences, where PDE researchers in East Asia participate every other year.
- "The Eighth East Asia Conference on PDE“ was held at Ohang University of Science and Technology in Korea.

Date

July 28–31, 2014

Conference Venue

Hotel Nikko Nara, Nara, Japan

Science Committee

Daomin Cao (AMSS, China)
Hi Jun Choe (Yonsei University, Korea)
Hideo Kozono (Waseda University, Japan)
Chang Shou Lin (National Taiwan University, Taiwan)
Takashi Suzuki (Osaka University, Japan)
Zhouping Xin (The Chinese University of Hong Kong, China)
Organizing Committee

Jaeyoung Byeon (KAIST, Korea)
Takayuki Kobayashi (Osaka University, Japan)
Hideo Kozono (Waseda University, Japan)
Ryo Takahashi (Osaka University, Japan)
Taku Yanagisawa (Nara Women University, Japan)

Sponsors

- JSPS Grant No. 24224003, Mathematical theory of turbulence by the method of modern analysis and computational science (Hideo Kozono)
- JSPS Grant No. 25400175, Diffusion wave property of the solutions to the system of the viscous fluid flow (Takayuki Kobayashi)
- JSPS Grant No. 23340036, Global structure in time of solutions for energy dissipative system of nonlinear conservation laws (Akitaka Matsumura)
- JSPS Grant No. 26247013, Mathematical analysis of dynamical models near from equilibria (Takashi Suzuki)
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<td>10:40-11:10</td>
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July 29 (Tues)

9:30~10:00 Zhouping Xin (*The Chinese University of Hong Kong*)
On Gases Expanding into Vacuum

10:10~10:40 Hailiang Li (*Capital Normal University*)
Global solution in large for 2D compressible Navier-Stokes equations with free boundary

10:40~11:10 Coffee Break

11:10~11:40 Jing Li (*Chinese Academy of Sciences*)
Some Uniform Estimates and Large-Time Behavior for One-Dimensional Compressible Navier-Stokes System in Unbounded Domains with Large Data

11:50~12:20 Zhifei Zhang (*Peking University*)
Global existence and decay of smooth solution for the 2-D MHD equations without magnetic diffusion

12:20~14:10 Lunch

14:10~14:25 Dugyu Kim (*Sogang University*)
$L^q$-estimates for the stationary Oseen equations on exterior domains

14:30~14:45 Minsuk Yang (*KIAS*)
Mixed norm estimates for the solution of the non-stationary Stokes system

14:45~15:15 Coffee Break

15:15~15:45 Kyungkeun Kang (*Yonsei University*)
Temporal asymptotics of Keller-Segel models coupled to the Navier-Stokes equations in two dimensions

15:45~18:00 Poster Session
–Poster Section–

Bambang Hendriya Guswanto (Osaka University)
Existence and Uniqueness of Mild Solutions for Fractional Semilinear Differential Equations

Byung Soo Kang (Sogang University)
$W^{1,p}$-estimates for linear elliptic equations of the second-order

Atsushi Kosaka (Osaka City University)
Asymptotic behavior of eigenvalues of Laplace-Beltrami operator in a spherical cap on $S^N$

Min Gi Lee (KAIST)
Formulation of Dirac Equation on lattice

Kota Uriya (Tohoku University)
Ill-posedness for the quadratic nonlinear Schrödinger equation with nonlinearity $|u|^2$

Zhi-An Wang (Hong Kong Polytechnic University)
Competing effects of attraction and repulsion in chemotaxis

Jingang Xiong (Peking University)
Schauder estimates for viscosity solutions of integro-differential equations

Ting Zhang (Zhejiang University)
Global wellposedness for the incompressible fluids system with some class of large initial velocity
July 30 (Wed)

9:30~10:00  Juncheng Wei  (The Chinese University of Hong Kong)
Classification and Application of SU(n + 1) Toda System

10:10~10:40  Hsin-Yuan Huang  (National Sun Yat-sen University)
On the Chern-Simons system with two Higgs particles

10:40~11:10  Coffee Break

11:10~11:40  Yong Jung Kim  (KAIST)
Thermal creep of a rarefied gas on the basis of non-linear Korteweg-theory

11:50~12:20  Takayoshi Ogawa  (Tohoku University)
End-point maximal $L^1$ regularity for parabolic equations and optimality

12:20~14:00  Lunch

14:00~18:00  Excursion

19:00~21:00  Banquet
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– Abstract –
INVITED TALKS

Solitary Waves for Nonlinear Schrödinger systems
Jaeyoung Byeon
KAIST, Korea

We introduce a variational construction of semi-classical one bump standing waves for Nonlinear Schrödinger systems. This is a joint work with Kazunaga Tanaka.

Study of the rotating spiral wave and rotating spot by the wave front interaction model
Yan-yu Chen
Tamkang University, Taiwan

Recently, there are many kinds of patterns appeared in our nature. For example, the spiral waves, traveling spots and rotating spots can be observed from the experiment of the photosensitive BZ reaction. In this talk, we focus on the spiral wave and rotating spot and treat them by the wave interaction model proposed by Zykov in 2007. First, we give the equations to describe the boundary of these two patterns. Then we prove the existence, uniqueness and asymptotic behavior for the spiral wave under certain condition for the core radius and angular speed. Finally, we show the existence of the rotating spot. These two works are joint works with professors J.-S. Guo and H. Ninomiya.

Caffarelli-Kohn-Nirenberg and Hardy-Sobolev Inequality with Boundary Singularities
Jann-Long Chern
National Central University, Taiwan

In this talk, we are interested in how the geometry of boundary singularities can affect the attainability of the respective best Caffarelli-Kohn-Nirenberg and Hardy-Sobolev constant.
Finite time blowup for mass critical fourth-order NLS
Yonggeun Cho
Chonbuk National University, Korea

In this talk, we will consider the finite time blowup for the mass-critical focusing fourth-order nonlinear Schrödinger equations with inhomogeneous power type or Hartree type nonlinearity. The models are the laser beam in Kerr media affected by electrons and Boson particles affected by self-gravitation. The equation will be mass-critical in the scaling and satisfy the mass and energy conservation laws. The main ingredient of this talk is to show the finite time blowup of this equation. We adopt Glassey’s virial argument. One may need some regularity of solutions but in general cannot get it due to the singularity of nonlinearity or low dispersion of phase of wave. To get around we consider regularized equations, approximating scheme of regularized solutions to original. For this purpose we assume the radial symmetry of solutions and negative energy of initial data. The focusing nonlinearity serves as an attracting potential. If the energy is negative (i.e. the magnitude of the potential energy is larger than that of kinetic part), then self-attracting power overwhelms the dynamics and so it results in a collapse of waves in a finite time. This talk is based on the joint work with T. Ozawa and C. Wang.

Characterization of generalized solutions for the homogeneous Stokes equations in exterior domains
Hi Jun Choe
Yonsei University, Korea

We let $K$ be a compact set of class $C^m$, $m \geq 2$ in and $\Omega \setminus K$ Without loss of generality, we assume $0 \in K$. We consider an incompressible, steady, viscous fluid in $\Omega$. As we know, Stokes equations are linearized equations of Navier-Stokes equations by disregarding of convection terms $v \cdot \nabla v$. It has been known that, for small Reynolds number (i.e., slow velocity, large viscosity or small bodies), the solution of the Stokes equations provides a good approximation to the solution of the Navier-Stokes equations for a region near body. On the other hand, all the Stokes solutions cannot account for the behavior of real fluids at infinity, which phenomena are called as Stokes paradox. This paper is a study for the Stokes equations, providing full characterizations of the homogeneous Stokes solutions with zero boundary data.

Large time asymptotics for the reduced Ostrovsky equation
Nakao Hayashi
Osaka University, Japan

We consider the Cauchy problem for the reduced Ostrovsky equation

$$u_{tx} = u + (u^3)_{xx}$$

with real valued initial data $u(0) = u_0$. We find the large time asymptotics of solutions to the Cauchy problem.
Realization in $R^3$ of two types of Riemannian manifolds with negative Gauss curvature
Feimin Huang
Chinese Academy of Sciences, China

The realization of abstract 2-D Riemannian manifold in $R^3$ is a fundamental and challenging problem in the field of differential geometry. The problem is equivalent to solve initial and/or boundary value problems of Gauss-Codazzi systems, which are of nonlinear partial differential equations of mixed elliptic-hyperbolic type. In this talk, I will show the isometric immersion in $R^3$ of two types of 2-D Riemannian manifolds with negative Gauss curvature. In particular, the result includes two important surfaces-catenoid and helicoid, and does not require any smallness of initial data.

On the Chern-Simons system with two Higgs particles
Hsin-Yuan Huang
National Sun Yat-sen University, Taiwan

In this talk, I will survey the recent developments of the system arising from the Chern-Simons Model with two Higgs Particles. Mathematically, the system is a typical skew-symmetric system. Thus, the action functional of this system is indefinite, which makes it difficult to study from the variational method. Among others, I will present my recent works on this system, including the uniqueness of the topological solutions and the radial non-topological solutions, and existence of bubbling solutions on a torus (Based on the joint work with C.S. Lin and Y.Lee).

On the existence and nonexistence of a maximizer for a variational problem for the Sobolev type embedding in $R^N$
Michinori Ishiwata
Osaka University, Japan

In this talk, we consider the attainability of a maximizing problem
\[ D := \sup_{u \in H^{1,N}(\mathbb{R}^N), \|u\|_{H^{1,N}}=1} \left( \|u\|_{N}^\gamma + \alpha \|u\|_{p}^p \right), \]

where $N \geq 2$, $N < p < \infty$, $\alpha > 0$, $0 < \gamma \leq N$ and $\|u\|_{H^{1,N}} = (\|u\|_{N}^\gamma + \|\nabla u\|_{N})^{\frac{1}{\gamma}}$. The existence and the nonexistence of a maximizer for $D$ is closely related to the exponent $\gamma$, namely, there exists $\alpha_*(\gamma)$ such that $D$ is attained for $\alpha > \alpha_*(\gamma)$ and not attained for $\alpha < \alpha_*(\gamma)$. Moreover, we show
\[ \alpha_*(\gamma) := \inf_{\|u\|_{H^{1,N}}=1} \left( \frac{1 - \|u\|_{N}^\gamma}{\|u\|_{p}} \right) \]

and identify the behavior of the curve $\gamma \mapsto \alpha_*(\gamma)$.

This is a joint work with H. Wadade, Kanazawa university.
Temporal asymptotics of Keller-Segel models coupled to the Navier-Stokes equations in two dimensions
Kyungkeun Kang
Yonsei University, Korea

We consider Keller-Segel models coupled to the Navier-Stokes equations describing the dynamics of oxygen, swimming bacteria living in viscous incompressible fluids in dimension two.

\[
\begin{align*}
\frac{\partial n}{\partial t} + u \cdot \nabla n - \Delta n &= - \nabla \cdot (\chi(c)n \nabla c), \\
\frac{\partial c}{\partial t} + u \cdot \nabla c - \Delta c &= -k(c)n, \\
\frac{\partial u}{\partial t} + u \cdot \nabla u - \Delta u + \nabla p &= -n \nabla \phi, \\
\text{div} u &= 0
\end{align*}
\]

in \(Q_T := (0, T) \times \mathbb{R}^2\), where \(c(t, x) : Q_T \to \mathbb{R}^+, n(t, x) : Q_T \to \mathbb{R}^+, u(t, x) : Q_T \to \mathbb{R}^2\) and \(p(t, x) : Q_T \to \mathbb{R}\) denote the oxygen concentration, cell concentration, fluid velocity, and scalar pressure, respectively. Here \(\mathbb{R}^+\) indicates the set of non-negative real numbers. The nonnegative functions \(k(c)\) and \(\chi(c)\) denote the oxygen consumption rate and the aerobatic sensitivity, respectively, i.e. \(k, \chi : \mathbb{R}^+ \to \mathbb{R}^+\) such that \(k(c) = k(c(x, t))\) and \(\chi(c) = \chi(c(x, t))\). The model above, formulating the dynamics of swimming bacteria, Bacillus subtilis, was proposed by Tuval, Cisneros, Dombrowski, Wolgemuth, Kessler, and Goldstein Tuval et al. (Bacterial swimming and oxygen transport near contact lines, PNAS, 102(7); 2277–2282, 2005).

We assume that the initial data \((n_0, c_0, u_0)\) are in \(H^{m-1}(\mathbb{R}^2) \times H^m(\mathbb{R}^2) \times H^m(\mathbb{R}^2)\) for \(m \geq 3\) with \(n_0 \geq 0\) and \(c_0 \geq 0\). Assume further that \(\chi, k, \chi', k'\) are all non-negative and \(\chi, k \in C^m(\mathbb{R}^+)\) and \(k(0) = 0, \|\nabla \phi\|_{L^1} < \infty\) for \(1 \leq |l| \leq m\). Suppose that there exists \(\varepsilon > 0\) such that

\[
\|n_0\|_{L^1(\mathbb{R}^2)} + \|c_0\|_{L^\infty(\mathbb{R}^2)} + \|\omega_0\|_{L^1(\mathbb{R}^2)} < \varepsilon,
\]

where \(\omega = \nabla \times u\). Then, our main result is as follows: Unique classical solutions \((n, c, \omega)\) of (1) exist globally and \((n, c, \omega)\) satisfy the following asymptotics: for any \(R < \infty\) and for all \(1 < r < \infty\)

\[
\lim_{t \to \infty} t^{1/2} \|c(\cdot, t)\|_{L^\infty(B_t(R))} = 0,
\]

\[
\lim_{t \to \infty} t^{1/2} \|\nabla c(\cdot, t)\|_{L^\infty(B_t(R))} = 0,
\]

\[
\lim_{t \to \infty} t^{1/2} \|\omega(\cdot, t) - \gamma \Gamma(\cdot, t)\|_{L^r(B_t(R))} = 0,
\]

where \(B_{t, R} := \{x \in \mathbb{R}^2 : |x| < Rt^{1/2}\}\) and \(\Gamma(x, t) = (4\pi t)^{-1} \exp(-|x|^2 / 4t)\).

This is a joint work with Myeongju Chae and Jihoon Lee.
$L^q$-estimates for the stationary Oseen equations on exterior domains

Dugyu Kim
Sogang University, Korea

In this talk, we study the Dirichlet problem for the stationary Oseen equations on exterior smooth domains $\Omega$ in $\mathbb{R}^n$, $n \geq 2$. Our main results are the existence and uniqueness of weak and very weak solutions of the Oseen equations satisfying appropriate $L^q$-estimates. The uniqueness of very weak solutions is shown by utilizing recent results for very weak solutions of the Stokes equations on bounded domains. Then for $(n+1)/(n-1) < q < \infty$, the existence and $L^q$-estimates of very weak solutions in $L^q(\Omega)^n$ is deduced by a duality argument from our existence result and $D^2$-estimates for strong solutions. These results, combined with some regularity results for very weak solutions, enable us to prove the existence, uniqueness and $D^{1,r}$-estimates of weak solutions in $D^{1,r}(\Omega)^n \cap L^{(n+1)r/(n+1-r)}(\Omega)^n$, where $(n+1)/n < r < n+1$. Here $D^{1,r}(\Omega)$ is the homogeneous Sobolev space.

Finally, applying our main results to the stationary Navier-Stokes equations on exterior domains $\Omega$ in $\mathbb{R}^3$, we establish the existence and uniqueness results for weak and very weak solutions.

This is a joint work with Professor Hyunseok Kim.

On weak solutions of linear elliptic equations with singular drift terms

Hyunseok Kim
Sogang University, Korea

We consider the Dirichlet problem for second-order linear elliptic equations with singular drift terms given by a vector field $u$. $W^{1,p}$-estimates for weak solutions are quite well-known, provided that $u$ is sufficiently regular, e.g., $u \in L^n$. In this paper, we establish the existence of weak solutions satisfying $W^{1,p}$- or $W^{2,p}$-estimates for less regular $u$. First, some $W^{1,p}$-estimates are shown for $u \in L^n_{\sigma} + L^r$, where $n \leq r < \infty$ if $n \geq 3$ and $2 < r < \infty$ if $n = 2$. Here $n$ denotes the dimension and $L^n_{\sigma} = \{ v \in L^n : \text{div} v = 0 \}$. The case of more singular $u$ is then studied. Assuming that $n \geq 3, u \in L^2$, and $\text{div} u \in L^{n/2}$, we prove the existence, uniqueness and $W^{1,2}$-estimate of weak solutions. Our $W^{1,p}$- and $W^{2,p}$-results are optimal in some sense, as shown by counterexamples due to Moscariello. This is based on a joint paper with Young-Heon Kim at the University of British Columbia, Canada.
Thermal creep of a rarefied gas on the basis of non-linear Korteweg-theory

Yong Jung Kim
KAIST, Korea

The study of thermal transpiration or more commonly called thermal creep is accomplished by use of Korteweg’s theory of capillarity. Incorporation of this theory into the balance laws of continuum mechanics allows resolution of boundary value problems via solutions to systems of ordinary differential equations. The problem was originally considered by J.C. Maxwell in his classic 1879 paper. In that paper Maxwell derived what is now called the Burnett higher order contribution to the Cauchy stress. But Maxwell was not able to solve his newly derived system of partial differential equations. In this paper the authors note that a more appropriate higher order contribution to the Cauchy stress follows from Korteweg’s 1901 theory. The appropriateness of Korteweg’s theory is based on the exact summation of the Chapman-Enskog expansion given by A. Gorban and I. Karlin. The resulting balance laws are solved exactly, qualitatively, and numerically and the results are qualitatively similar to the numerical and exact results given by Aoki et al., Loyalka et al., and Struchtrup et al.

Estimates of the mean field equations with integral singular sources

Ting-Jung Kuo
National Taiwan University, Taiwan

Abstract: Let $M$ be a compact Riemann surface, $\alpha_j \in \mathbb{N}$ and $h(x)$ be a positive $C^2$ function of $M$. In this paper, we consider the following mean field equation:

$$\Delta u(x) + \rho \left( \frac{h(x) e^{u(x)}}{\int_M h(x) e^{u(x)}} - \frac{1}{|M|} \right) = 4\pi \sum_{j=1}^{d} \alpha_j \left( \delta_{q_j} - \frac{1}{|M|} \right) \text{ in } M.$$

We prove that for any $\rho > \rho_0$, the equation has one solution at least if the Euler characteristic $\chi(M\setminus\{q_1, \ldots, q_d\}) \leq 0$, where $\rho_0 = \max_M (2K - \ln h + N^*)$, $K$ is the Gaussian curvature and $N^* = 4\pi \sum_{j=1}^{d} \alpha_j$. Our proof relies on the bubbling analysis at the blowup point $q_j$, where the bubbling behavior might be simple as well as non-simple. (joint work with Chang-Shou Lin)
Well-posedness of some fluid-particle interaction models
Jihoon Lee
Chung-Ang University, Korea

In this talk, we consider partial differential equations which is originated from spray model. This model describes the dynamics of the dispersed phase in an underlying fluids. Its study can be considered as a subdomain of the study of multiphase flow. In our model, dynamics of fluid is described by the Navier-Stokes equations and particle distribution is described by the Vlasov or Vlasov-Fokker-Planck type equation. We consider the global-in-time existence issue for this coupled system. Also we consider some other properties for this system. This is the joint work with Myeonju Chae and Kyungkeun Kang.

Global solution in large for 2D compressible Navier-Stokes equations with free boundary
Hailiang Li
Capital Normal University, China

In this talk, we present some recent results on global existence of strong solution to free boundary value problem for 2D compressible Navier-Stokes equations for general large initial data.

Some Uniform Estimates and Large-Time Behavior for One-Dimensional Compressible Navier-Stokes System in Unbounded Domains with Large Data
Jing Li
Chinese Academy of Sciences, China

This talk is concerned with the large-time behavior of solutions to the initial and initial boundary value problems with large initial data for the compressible Navier-Stokes system describing the one-dimensional motion of a viscous heat-conducting perfect polytropic gas in unbounded domains. The temperature is proved to be bounded from below and above independently of both time and space. Moreover, the global solution is showed to be asymptotically stable as time tends to infinity. Note that the initial data can be arbitrarily large. This result is proved by using elementary energy methods.

Regularity for the p-harmonic map heat flows
Masashi Misawa
Kumamoto University, Japan

We study regularity for the evolution of $p$—harmonic maps between two smooth compact Riemannian manifolds. We devise a new monotonicity type formula of a scaled energy and establish a criterion for a uniform regularity estimate for regular $p$—harmonic map heat flows. As an application we show the global in time existence of regular $p$—harmonic map heat flow.
End-point maximal $L^1$ regularity for parabolic equations and optimality

Takayoshi Ogawa

Tohoku University, Japan

In this talk, we would like to discuss maximal regularity on a parabolic equation in the end point time space. Over the UMD Banach space, the general theory ensures that maximal regularity for parabolic equation is well established in time Lebesgue spaces $L^p$. However since UMD is necessarily reflexive, whenever we consider non-reflexive Banach spaces such as $L^1$, the general theory is not available and we necessarily employ a special method depending on each cases. Here we show maximal $L^1$ regularity for a parabolic equations including the heat equations and discuss its optimality. In particular, we derive optimal maximal regularity for time $L^1$ spaces for the solution of the parabolic equation with variable coefficient case. We also compare known results on the heat equations. (based on joint work with Senjo Shimizu).

Local asymptotic nondegeneracy for multi-bubble solutions to the biharmonic Liouville-Gel’fand problem in dimension four

Futoshi Takahashi

Osaka City University, Japan

In this talk, we consider the fourth order Liouville-Gel’fand problem with the Navier boundary conditions

\[
\begin{aligned}
\Delta^2 u &= \lambda e^u & \text{in } \Omega, \\
u &= \Delta u &= 0 & \text{on } \partial \Omega
\end{aligned}
\]

where $\Omega \subset \mathbb{R}^4$ is a smooth bounded domain, and $\lambda > 0$ is a parameter.

Let $\{u_n\}$ be a solution sequence for $\lambda = \lambda_n \downarrow 0$ as $n \to \infty$. Under the nondegeneracy assumption of blow up points of multiple blowing-up solutions $\{u_n\}$, we prove several estimates for the linearized equations and obtain some convergence result. The result can be seen as a weaker version of the asymptotic nondegeneracy of multi-bubble solutions, which was recently established by Grossi-Ohtsuka-Suzuki (2011) in two-dimensional Laplacian case.

This talk is based on a joint work with H. Ohtsuka (Kanazawa university).
Modified Strichartz estimates and applications to nonlinear Schrödinger equations
Takeshi Wada
Shimane University, Japan

In the proof of well-posedness for nonlinear wave or dispersive equations, a series of inequalities called Strichartz estimates has made an important role. They are inequalities estimating solutions in the form of spacetime integrability properties.

Pecher (1997) proved a modification of Strichartz estimate for the Schrödinger equation, which estimates the solution in function spaces containing the time-derivative, or more precisely in $B^{0}_{q,2}(R;L^r(R^n))$. As an application, he considered the following nonlinear Schrödinger equation with power type nonlinearity in the spacetime $R^{1+n}$:

$$\partial_t u + i\Delta u = \lambda |u|^{p-1}u,$$  \hspace{1cm} (1)

where $\lambda \in C$ and $p > 1$, and proved the well-posedness of (1) in the case where $p$ is close to 1 so that the nonlinear term is not so smooth. Unfortunately, Pecher’s estimate is not scale-invariant and hence he could not treat the critical case in $H^s$ with $s < n/2$, namely when $p = 1 + 4/(n - 2\sigma)$. In this talk we aim at improving Pecher’s estimate to the scale invariant form and solving (1) in the critical case. (Joint work with M. Nakamura, Yamagata University)

Classification and Application of SU(n+1) Toda System
Juncheng Wei
The Chinese University of Hong Kong, China

First we give a complete classification (including quantization and nondegeneracy) of $A_n$ Toda system with single source. Then we give several applications of such analysis, such as construction of non-topological solutions of $A_2, B_2, G_2$ Chern-Simons-Higgs system, critical parameters for mean field Toda system, sharp analysis of mean field Toda, and topological degree counting formula for Toda system on Riemann surfaces.

Some studies for the rotating shallow water system
Chunjing Xie
Shanghai Jiao Tong University, China

In this talk, we discuss both the well-posedness and ill-posedness theory for the rotating shallow water system. We exploit the dispersion mechanism produced the rotating force and use it to prove the global well-posedness for smooth solutions with a large class of initial data. On the other hand, we show the ill-posedness of the system for the general data.
On Gases Expanding into Vacuum
Zhouping Xin
The Chinese University of Hong Kong, China

In this talk I will discuss several issues concerning the motion of gases expanding into vacuum with/or without self-gravitiation, which is governed by a free boundary value problem for the 3-dimensional compressible Euler system (or Navier-Stokes equations) with/or without Poisson equation. A general uniqueness theorem for classical solutions to such a free boundary value problem for the ideal case is presented for physical vacuum. A typical physical vacuum solution includes the famous Lane-Emden solutions for gaseous stars. The uniqueness is proved by a relative entropy argument. Then a local well-posedness theory for spherically symmetric motions is established in a less regular space. Finally, I will discuss the nonlinear stability of the Lane-Emden solutions for the viscous gaseous star problem. These are joint works with Professor Tao Luo and Professor Huihui Zeng.

Mixed norm estimates for the solution of the non-stationary Stokes system
Minsuk Yang
KIAS, Korea

We study the boundary value problem of the non-stationary Stokes system in space dimension 3. We provide pointwise estimates for fundamental tensors of the nonstationary Stokes system in the half space, which make it possible to control the nontangential behavior of the solutions. With the layer potential representations we find mixed norm estimates of nontangential maximal functions of the solutions by the boundary data. Furthermore our estimate could improve the mixed norm estimate of nonhomogeneous Stokes system by Solonnikov.

Global existence and decay of smooth solution for the 2-D MHD equations without magnetic diffusion
Zhifei Zhang
Peking University, China

We prove the global existence and the decay estimates of small smooth solution for the 2-D MHD equations without magnetic diffusion. This confirms the numerical observation that the energy of the MHD equations is dissipated at a rate independent of the ohmic resistivity.
Existence and Uniqueness of Mild Solutions for Fractional Semilinear Differential Equations

Bambang Hendriya Guswanto
Osaka University, Japan

Let $H$ be a Banach space. We consider the fractional semilinear differential equation

\begin{align}
D_a^\alpha u &= Au + f(u), \quad t > 0 \\
u(0) &= u_0,
\end{align}

where $0 < \alpha < 1$, $u_0 \in H$, $A : D(A) \subset H \to H$ is a sectorial linear operator, $D_a^\alpha$ is the Caputo fractional derivative of order $\alpha$, and $f$ is a nonlinear operator in $H$ satisfying

(i) $f(0) = 0$,

(ii) there exist $C_0 > 0$, $\vartheta > 1$, and $0 < \beta < 1$ such that

\[ \| f(u) - f(v) \| \leq C_0 (\| A^\beta u \| + \| A^\beta v \|) \vartheta^{-1} \| A^\beta u - A^\beta v \|, \]

for all $u, v \in D(A^\beta)$

where $A^\beta$ denotes the fractional power of $A$. We obtain the existence and uniqueness of mild solutions to the problem (1) under certain conditions. An example for the application of our results is also given.

This is a joint work with Professor Takashi Suzuki.
$W^{1,p}$-estimates for linear elliptic equations of the second-order
Byung Soo Kang
Sogang University, Korea

We consider the Neumann and Dirichlet problems for second-order linear elliptic equations
\[-\text{div} (A\nabla u) - b \cdot \nabla u + \lambda u = f\]
and
\[-\text{div} (A'\nabla v) + \text{div} (bv) + \lambda v = g\]
in a bounded Lipschitz domain $\Omega \subset \mathbb{R}^n$, $n \geq 2$. $W^{1,2}$-estimates are already known provided that $A \in L^r(\Omega)^{n^2}$ and $b \in L'(\Omega)^n$, where $n \leq r < \infty$ if $n \geq 3$ and $2 < r < \infty$ if $n = 2$. For $W^{1,p}$-estimates, more regularity assumptions are imposed on the coefficient matrix $A$ and domain $\Omega$. The matrix $A$ is supposed to be only measurable in one direction and have locally small BMO semi-norms in other directions. Additionally, we assume that $A$ has small BMO semi-norms in a neighborhood of the boundary of the domain. The domain $\Omega$ is supposed to have Lipschitz boundary with small Lipschitz constant. Under these assumptions on $b$, $A$ and $\Omega$, we establish the existence and uniqueness of weak solutions satisfying $W^{1,p}$-estimates. For the Neumann problem with $\lambda = 0$, the existence and $W^{1,p}$-estimates are shown for some compatibility conditions. For the Neumann problem with $\lambda > 0$, the $W^{1,p}$-estimates are uniform with respect to $\lambda$ if $f$ and $g$ satisfy the compatibility conditions.

This is a joint work with Professor Hyunseok Kim.
Asymptotic behavior of eigenvalues of Laplace-Beltrami operator in a spherical cap on $S^N$
Atsushi Kosaka
Osaka City University, Japan

We consider the following eigenvalue problem
\begin{align}
-\Lambda_N u &= \lambda u \quad \text{in } B_{\pi-\varepsilon}, \\
(cos \sigma) \partial_n u + (sin \sigma) u &= 0 \quad \text{on } \partial B_{\pi-\varepsilon},
\end{align}
where $\Lambda_N$ is the Laplace-Beltrami operator in $S^N$ ($N \geq 2$), $B_{\pi-\varepsilon} \subset S^N$ is a geodesic ball whose origin is at the North Pole $P = (0,0,\ldots,0,1)$, the geodesic radius of $B_{\pi-\varepsilon}$ is $\pi - \varepsilon$ ($0 < \varepsilon < \pi$), $\partial_n u := \nabla u \cdot n$, $n$ is an outer unit normal vector on $\partial B_{\pi-\varepsilon}$, $\lambda > 0$ and $\sigma \in (0,\pi/2]$.

It is well-known that eigenvalues of
\begin{align}
-\Lambda_N u &= \lambda u \quad \text{on } S^N
\end{align}
are $j(j+N-1)$ ($j \in \mathbb{N} \cup \{0\}$). If $\varepsilon \searrow 0$, then (1) is considered as the perturbation problem corresponding to (2). Thus, we investigated (1) under $N = 2,3$ and proved that, for any $j \in \mathbb{N} \cup \{0\}$, there exist $(j+1)$ eigenvalues of (1) near $j(j+N-1)$ if $\varepsilon$ is sufficiently near 0. Moreover we obtain asymptotic formulas of those eigenvalues as $\varepsilon \searrow 0$.

This is a joint work with Professors Yoshitugu Kabeya, Tatsuki Kawakami and Hiroyuki Ninomiya.
Formulation of Dirac Equation on lattice
Min Gi Lee

KAIST, Korea

We consider a long-standing problem of Quantum Lattice Field theory, that is to formulate Dirac equation on a lattice. Mathematically, it is to compose a numerical scheme of Dirac equation that keeps all the symmetries the equation possesses, the two U(1) symmetries and invariance under Lorentz transforms. Other than equations arose in the Standard Model, such as wave type equations of Klein-Gordon, Maxwell, and Yang-Mills, the Dirac equation on lattice has been remained to be unsatisfactory, in a sense that the composed scheme carries only a part of symmetries or is the one with spectrum degeneracy. It is surprising that a theorem stating this failure is unavoidable under quite reasonable assumptions was proved in 1981 by Nielson and Ninomiya.

In the talk, we first point out that there is an exactly same failure in discretizing the Cauchy-Riemann operator in 2-dimensions, which is on a complex-valued function as well. Then we report the well-known resolution of the failure for the Cauchy-Riemann operator, that is to form a div-curl system on a vector field consists of the real and imaginary part of the complex-valued function. This transition can be performed systematically by abstract recipe that concerns algebraic structures of symmetries the equation possesses.

We apply the same idea to the Dirac operator with the recipe. More specifically, this is to modify the Ivanenko-Landau-Kähler equation on exterior algebra, which was suggested in 1928 by Ivanenko and Landau. We compose a numerical scheme based on the the canonical discretization of exterior algebra. It turns out to be the one without spectrum degeneracy, and that fulfill all the symmetries. We demonstrate that the very tricky part of the assumptions of Nielson-Ninomiya theorem is broken in this scheme.

References

Ill-posedness for the quadratic nonlinear Schrödinger equation with nonlinearity $|u|^2$

Kota Uriya

Tohoku University, Japan

We consider the ill-posedness issue for the quadratic nonlinear Schrödinger equation with the nonlinearity $|u|^2$ and prove the norm inflation in the dimensions $1 \leq n \leq 3$. Introducing the asymptotic expansion of the solution, we construct the sequence of the initial data to show the result. This is a joint work with professor Tsukasa Iwabuchi (Chuo University).

Competing effects of attraction and repulsion in chemotaxis

Zhi-An Wang

Hong Kong Polytechnic University, China

Abstract: Most of past and current researches on chemotaxis models deal with attraction and repulsion separately. But in some biological processes (or experiments), species often interact with the combined attraction and repulsion to accomplish some biological functions such as the aggregation of Microglia in the central nervous system in Alzheimer’s disease or the quorum sensing effect. In these scenarios, a model with both chemotactic attraction and repulsion will be more realistic than the attraction or repulsion alone. Here we shall present the first mathematical results on the so-called attraction-repulsion chemotaxis model and show the competing effects of these two biological processes. Various dynamics such as global boundedness, blowup behavior and pattern formations will be discussed. Open questions will be proposed for interested researchers.

Schauder estimates for viscosity solutions of integro-differential equations

Jingang Xiong

Peking University, China

Integro-differential equations appear naturally when studying discontinuous stochastic processes. We will talk about the regularity of viscosity solutions of integro-differential Bellman equations, and present our recent work on Schauder estimate. As the order of the equations approaching to 2, the Schauder estimate does not blow up and thus enable us to recover the classical Schauder estimate for second order elliptic equations. This is joint work with Dr Tianling Jin.
Global wellposedness for the incompressible fluids system with some class of large initial velocity

Ting Zhang
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In this talk, we consider the following 3-D incompressible inhomogeneous Navier-Stokes equations with initial data in the critical Besov spaces

\[
\begin{aligned}
\partial_t \rho + u \cdot \nabla \rho &= 0, \quad x \in \mathbb{R}^3, \quad t > 0, \\
\partial_t (\rho u) + \text{div} (\rho u \otimes u) - \Delta u + \nabla P &= 0, \\
\text{div} u &= 0, \quad (\rho, u)|_{t=0} = (\rho_0, u_0),
\end{aligned}
\]

where \( \rho, u \) and \( P \) denote the density, velocity and pressure of the fluid respectively. Using the incompressible condition and the nonlinear structure, we obtain the existence and uniqueness of the global solution when

\[
\| \rho^{-1} - 1 \|_{\dot{B}^{1}_{p,1}} \ll 1,
\]

and

\[
\| u_0^\alpha \|^\frac{1}{\alpha} \| u_0^\beta \|^\frac{1}{\beta} + \| u_0^{\alpha-\beta} \|^\frac{1}{\alpha-\beta} \| u_0^\beta \|^\frac{1}{\beta} \ll 1,
\]

where \( 1 < p < 6 \), \( \varepsilon \in (0, \frac{6}{p} - 1) \),

\[
\alpha = \begin{cases} 
\frac{1}{p}, & 1 < p < 5 \\
\varepsilon, & 5 \leq p < 6.
\end{cases}
\]

This result implies the global well-posedness of this system with large initial vertical velocity component, and improve the recently results of M.Paicu, P.Zhang (J.Funct.Anal. 262 (2012) 3556-3584).